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Original Article

Post-Flash Flood Disaster Management in Nagari Limo Kaum, Tanah Datar Regency, West Sumatra Province, Indonesia

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ABSTRACT
His study aims to analyze: 1) the spatial distribution of post-flash flood events, including the affected areas and severity of impacts, as well as accessibility conditions. 2) the post-flash flood disaster management system, encompassing aspects of preparedness, mitigation, rehabilitation, and recovery. This study used a mixed method, combining quantitative and qualitative approaches. The population included all hamlets (jorong) in Limo Kaum Village, with samples from four affected hamlets. Informants were selected using purposive sampling. Data were collected through observation, interviews, documentation, and spatial mapping. The results showed: 1) the distribution of flood impacts was uneven, with the highest level of damage occurring in Tuo Hamlet, at 7.36% of the total area. Impacts included damage to houses, agricultural land, public facilities, and disruption to accessibility between hamlets. 2) the post-disaster management system was not yet optimal. Preparedness and mitigation remain low, and rehabilitation focuses more on physical infrastructure, while social and psychological aspects have not been fully addressed. Community capacity building, improved early warning systems, and better cross-sector coordination are needed for sustainable disaster management.

KEYWORDS
Flash Floods, Spatial Distribution, Post-Disaster Management, Nagari Limo Kaum

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INTRODUCTION

Tourism is one of the key sectors in Indonesia, an archipelagic nation situated between the continents of Asia and Australia and the Pacific and Indian Oceans. This geographical position provides an abundance of natural resources, but at the same time makes Indonesia vulnerable to natural disasters. Geological conditions along the Ring of Fire, a tropical climate with high rainfall, and hydrological factors make this region prone to earthquakes, tsunamis, volcanic eruptions, landslides, and flash floods (Kurniawan, 2022; Isfahani et al., 2020). The disaster management paradigm in Indonesia has shifted from a focus on emergency response toward disaster risk reduction, which emphasizes mitigation, preparedness, and community capacity building. This aligns with Law No. 24 of 2007 on Disaster Management, which prioritizes prevention and mitigation as strategic measures (Darmadi, 2021).

West Sumatra Province is classified as a region with a high level of disaster vulnerability. Geologically, this region lies along a tectonic plate subduction zone and is surrounded by active volcanoes. A combination of natural and anthropogenic factors, such as illegal logging and land-use conversion, increases the risk of disasters, including flash floods. One major disaster that occurred was the flash flood in Tanah Datar Regency on May 11, 2024, caused by heavy rainfall on the slopes of Mount Marapi, which carried cold lava material downstream. Nagari Limo Kaum was one of the areas severely affected.

Limo Kaum Village spans approximately 2,300 hectares and comprises eight sub-villages, including Dusun Tuo, Balai Labuah Atas, Balai Labuah Bawah, and Piliang, which sustained significant damage. The disaster's impacts included damage to homes, infrastructure, agricultural land, public facilities, disrupted accessibility, and even loss of life. Data from the Regional Disaster Management Agency (BPBD) (2024) recorded 42 damaged homes (severe, moderate, and minor) and four affected public facilities.

Various previous studies on post-flash-flood disaster management in several countries have revealed diverse approaches and findings that can be compared to the conditions in Nagari Limo Kaum, Tanah Datar Regency. Pascual et al. (2024) and Kurata et al. (2023) in the Philippines highlight the importance of community behavior and preparedness in post-flood recovery, while Nagamani et al. (2024) in the Himalayan region emphasize geographical factors and extreme rainfall as the primary causes of flash floods. Gupta et al. (2012), through a case study in Leh, India, discuss emergency response management, including evacuation and coordination of health services, while Adhikari et al. (2023) in Nepal examine the impacts of infrastructure and socioeconomic factors on the post-flood recovery process. A study in Japan by J-STAGE (2022) discusses the restoration of clean water systems and basic services after floods, and research by Japan Disaster Research (2021) outlines multisectoral coordination in disaster recovery.

This study fills a gap in the literature and current practice by introducing a hybrid approach that combines high-resolution geospatial techniques, community participation (PGIS), inter-institutional coordination protocols tailored to the nagari structure, and contextual mitigation education packages. The results are expected to yield (1) accurate spatial impact maps at the village scale for rapid prioritization, (2) operational coordination protocols that reduce role confusion and accelerate the implementation of rehabilitation and reconstruction, and (3) mitigation education strategies that enhance the preparedness and adaptive capacity of the community in Nagari Limo Kaum.

Given this background, this study aims to analyze (1) the spatial distribution of the aftermath of the flash flood in Nagari Limo Kaum and (2) the post-disaster management system that was implemented. This study is expected to contribute to more structured, coordinated, and sustainable disaster management planning in disaster-prone areas.

METHOD

This study employs a mixed-methods approach (quantitative and qualitative) with GIS-based spatial analysis to describe the distribution of affected areas and the post-flash flood management system in Nagari Limo Kaum, Tanah Datar Regency. The study area encompasses four affected jorong: Dusun Tuo, Balai Labuah Atas, Balai Labuah Bawah, and Piliang. Primary data were collected through field surveys, GPS measurements, damage assessments, and interviews with village officials, the Regional Disaster Management Agency (BPBD), and affected residents,

while secondary data were sourced from administrative maps, rainfall records, BPBD reports, satellite imagery, and relevant literature. Sampling was conducted using a purposive approach targeting areas and informants with experience ranging from emergency response to reconstruction. Data analysis included mapping the distribution of damage using ArcGIS and descriptive analysis of aspects of preparedness, mitigation, emergency response, rehabilitation, and reconstruction. The research results are presented in the form of maps, tables, and descriptive narratives to provide a comprehensive overview of post-flash flood management in Nagari Limo Kaum.

Research Location

Pemilihan Nagari Limo Kaum, Kecamatan Limo KaumTanah Datar Regency, West Sumatra Province, was selected as the study site based on several rational considerations relevant to the focus of the study. First,

this region is classified as an area with a relatively high level of disaster vulnerability, both from geographical and social perspectives. The hilly topography and river systems make Nagari Limo Kaum vulnerable to natural disasters such as floods, landslides, and earthquakes, which frequently strike the West Sumatra region. This vulnerability is exacerbated by the increasing land-use activities that do not always take into account the environment's carrying capacity.

Second, empirical evidence shows that when disasters strike, Nagari Limo Kaum faces various fundamental challenges, including weak inter-agency coordination, suboptimal planning and implementation of rehabilitation and reconstruction programs, and a lack of accurate spatial data on the affected areas. These issues hinder the effectiveness of disaster response and have a direct impact on the community, particularly regarding aid distribution and post-disaster recovery efforts. Therefore, this research is important to conduct in Nagari Limo Kaum to examine how an integrative approach can be applied at the local level.

Third, from a socio-cultural perspective, Nagari Limo Kaum is one of the traditional villages in Tanah Datar Regency with a distinctive local governance structure. The integration of formal governance systems and traditional institutions makes Nagari Limo Kaum a representative example for understanding the dynamics of inter-institutional coordination within a local cultural context. This uniqueness presents an opportunity to develop coordination protocols and mitigation strategies that are more contextually appropriate and can be replicated in other traditional villages across West Sumatra.

Fourth, the selection of this location also took into account its academic and practical significance. Academically, research in Nagari Limo Kaum can fill a gap in the literature regarding the mapping of disaster impacts at the micro level while also making a methodological contribution by integrating geospatial technology and community participation. Practically, the research results are expected to serve as policy recommendations that can be directly utilized by the village government, local government, and relevant agencies to strengthen post-disaster management.

Research Approach

This study employs a mixed-methods approach, in which quantitative and qualitative data are collected and analyzed simultaneously, and the results are then compared and integrated (Sugiyono, 2021). The quantitative approach was used to analyze the spatial distribution of areas affected by flash floods using Geographic Information System (GIS) technology. Spatial data were analyzed to map the distribution of damage, severity, and correlations with topographic factors and river networks.

A qualitative approach was used to gather in-depth information on the post-disaster management system, covering the stages of preparedness, mitigation, emergency response, rehabilitation, and reconstruction. Qualitative data was collected through in-depth interviews, direct observation, and field documentation. The combination of these two approaches aims to provide a comprehensive picture of post-disaster conditions in Nagari Limo Kaum, both spatially and from the perspective of local-level policies and management practices.

Research Procedures

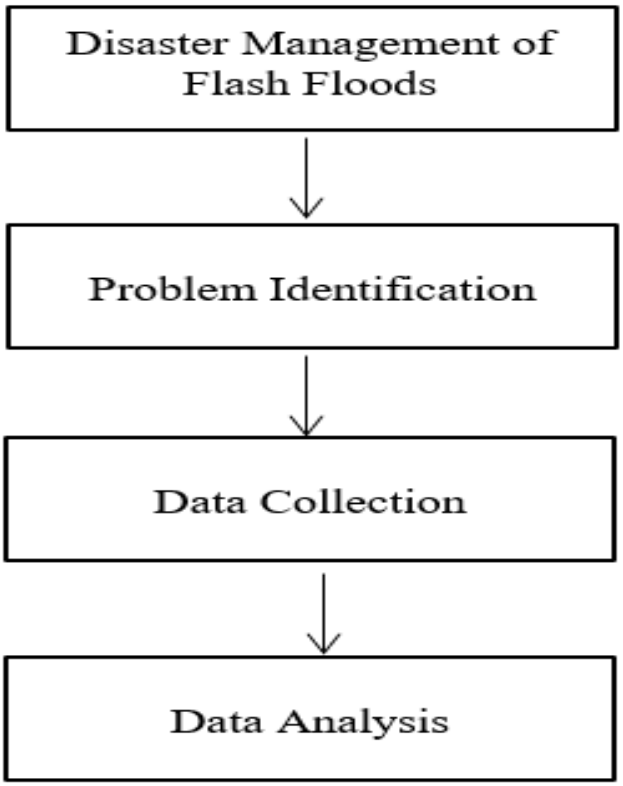

Figure 2. Flow Chart

This research procedure began with the preparatory phase, which included drafting the proposal, obtaining permits, and preparing the research instruments. Data collection was conducted through field observations, GPS-based measurement of damage site coordinates, in-

depth interviews with the BPBD, village officials, and affected communities, as well as documentation of post-disaster conditions. Secondary data were obtained from administrative maps, satellite imagery, official BPBD reports, and relevant literature. Spatial data were processed using ArcGIS through overlay analysis to map the distribution of damage, while qualitative data were analyzed descriptively through reduction, presentation, and drawing of conclusions. The final results are presented in the form of maps, tables, and narratives to illustrate the spatial distribution and post-disaster management system in Nagari Limo Kaum.

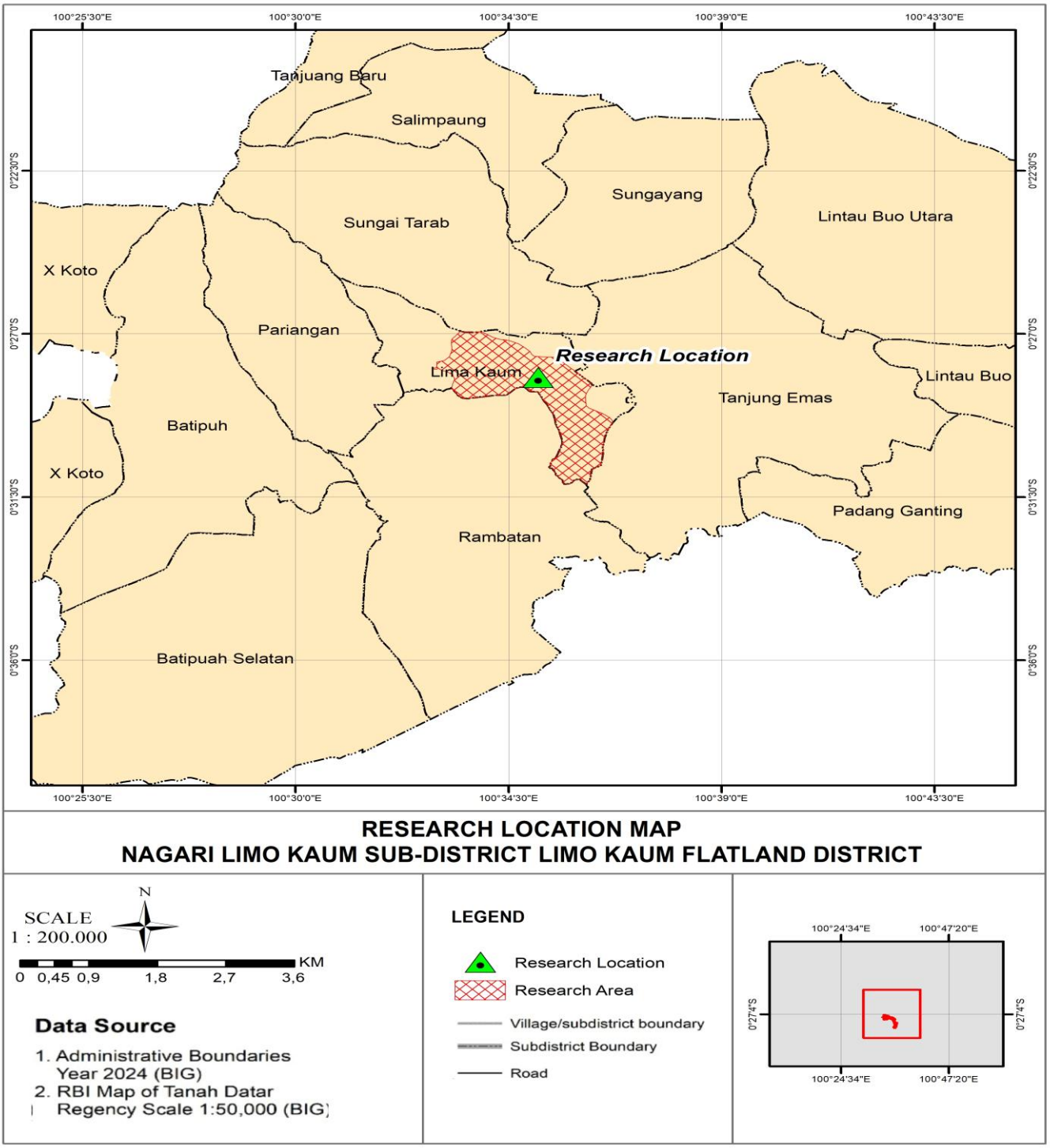

Figure 1. Research Location Map

Data Collection Tools

The instruments used in this study consisted of: (1) An observation sheet to record the physical conditions of the areas affected by the flash flood, including damage to infrastructure, land, and public facilities; (2) GPS devices to obtain the coordinates of damage sites as semi-structured spatial data containing a questionnaire regarding the post-disaster management system, intended for village officials, BPBD officers, and affected communities; and (4) Documentation templates to record visual evidence of damage and post-disaster response activities. These instruments were used in an integrated manner to obtain quantitative and qualitative data relevant to the research objectives.

Table 1. Observation questions

No.	Question
1.	What steps did you take in the aftermath of the flash flood?
2.	What challenges did you face in coordinating between agencies after the flash flood?
3.	How were you involved in the recovery process following the flash flood?
4.	What was the condition of infrastructure, such as roads and bridges, after the flash flood?
6.	Are there any disaster preparedness training or education programs provided to the community?
7.	What technology do you use in post-flood disaster management?
8.	What are the main policies you implement in managing flash floods?
9.	What are your expectations regarding the recovery process carried out by the government?

Data Analysis

Data analysis was conducted by combining quantitative and qualitative approaches. Quantitative data, consisting of the coordinates of damage sites, were processed using ArcGIS software through a digitization process. Several maps were overlaid, including administrative village maps to delineate the study area and conduct analysis by sub-village, topographic maps to assess the relationship between damage and elevation and slope conditions, and river network maps to identify the relationship between damage distribution and river flow as the primary trigger for flash floods. This combination of maps serves not only to produce a map of the affected areas but also to provide a more detailed spatial understanding of the environmental factors influencing the extent of damage. Analysis and buffering techniques were employed to map the distribution of affected areas, calculate the percentage of damaged area per jorong, and assess the relationship with topographic conditions and the river network. Qualitative data from interviews and observations were analyzed descriptively through the stages of data reduction, data presentation, and drawing conclusions, with information grouped based on post-disaster management themes (preparedness, mitigation, emergency response, rehabilitation, and reconstruction). The analysis results are presented in the form of maps, tables, and narratives to provide a comprehensive overview of the post-flash flood conditions in Nagari Limo Kaum.

RESULTS AND DISCUSSION

Spatial Distribution Following a Flash Flood

The results of the spatial analysis show that the flash flood on May 11, 2024, in Nagari Limo Kaum affected four jorong: Dusun Tuo, Balai Labuah Atas, Balai Labuah Bawah, and Piliang, To determine the extent of the flash flood's impact on each hamlet in Nagari Limo Kaum, the percentage of the affected area relative to the total area of the hamlet was calculated using the following formula:

$$\text{Percentage} = \frac{\text{Area Affected}}{\text{Total area}} \text{ x } 100\%$$

Source: Purcell, E. J., & Varberg, D (2020)

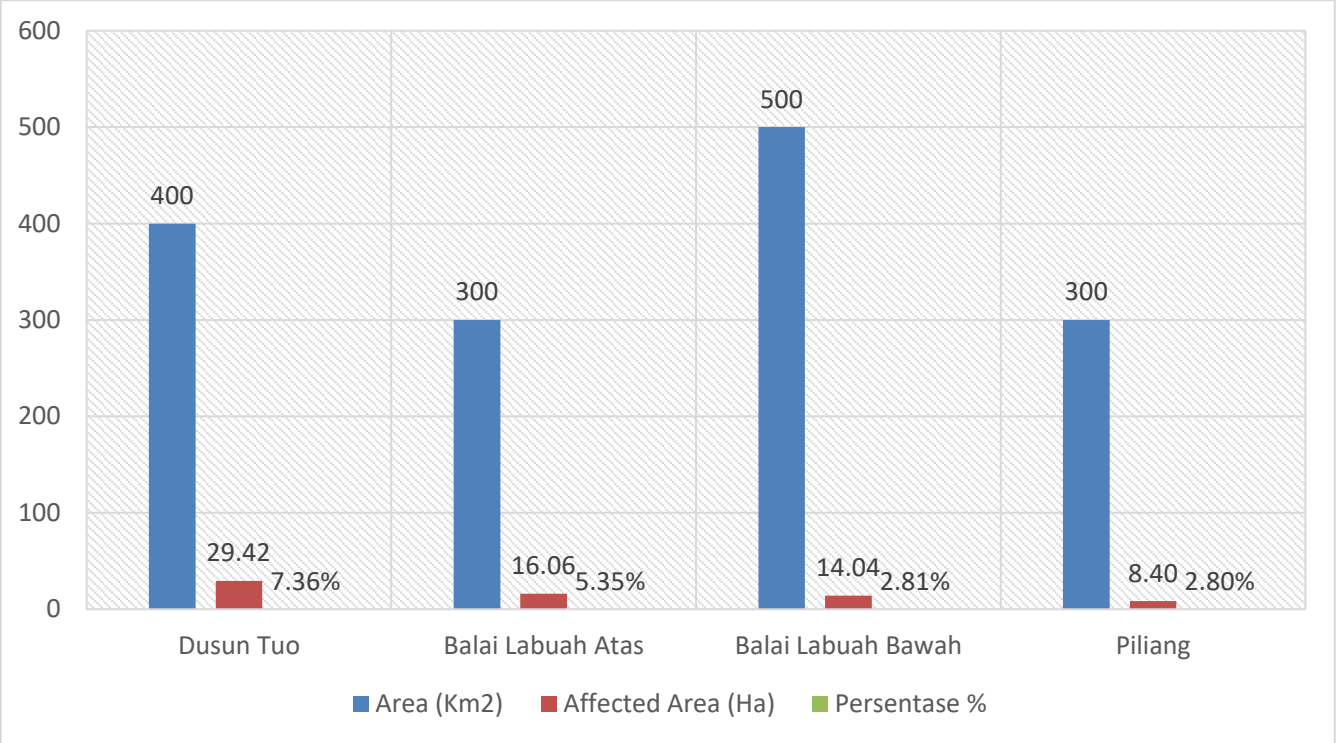

Figure 2. Percentage of the area affected by flash floods in Nagari Limo Kaum

Figure 3. Documentation with Residents Affected by Flash Floods

Figure 4. Environmental Documentation Following the Flash Flood Disaster

Based on the calculations presented in the table above, it can be seen that the extent of the flash flood's impact on each jorong in Nagari Limo Kaum varies significantly, with a total affected area of approximately 112.4 hectares. The highest percentage of damage occurred in Balai Labuah Atas (38%), followed by Balai Labuah Bawah (27%), Dusun Tuo (21%), and Piliang (14%). The damage distribution pattern was identified as clustered, following the course of the Batang Selo River and its tributaries. Concentrations of mud, rocks, and timber were found in low-lying areas that served as floodwater accumulation points.

Table 2. Damage Caused by Flash Floods in Tanah Datar in 2024

No	Type of Damage	Total Damage
1.	Minor Damage to Houses	21 Houses
2.	Moderate Damage to Houses	10 Houses
3.	Minor Damage to Houses	11 Houses
4.	General Damage	4 Buildings
	Total	46 Cases of Damage

Source: BPBD Tanah Datar 2024

The data shows that 46 houses sustained damage ranging from severe to minor. In addition, four public facilities were also damaged. The damage was spread across eight villages within a single subdistrict—Limo Kaum Subdistrict—which was the area most severely affected by this disaster.

These findings are consistent with the view of Erna Juita (2021), who states that the spatial distribution of disasters is strongly influenced by physical factors such as slope gradient, elevation, soil texture, land use, rainfall, and proximity to river channels. These findings also align with the research by Rahmawati et al. (2021), which states that downstream areas with relatively gentle topography serve as accumulation zones for flash flood debris. The clustered pattern indicates that damage is concentrated in areas directly connected to river channels, making spatial planning-based mitigation essential to minimize future losses.

However, to ensure the originality of this study and strengthen the results of the GIS-based spatial analysis, empirical field data obtained through ground-truthing activities is required. Direct validation in the field can provide concrete evidence regarding the extent of damage, the types of materials carried, geomorphological conditions, and the impacts on infrastructure and community land. With field verification, the research results are not solely based on spatial data processing but also have an empirical observational foundation that can enhance their reliability and contribution as original research. For further clarification, please refer to the following figure:

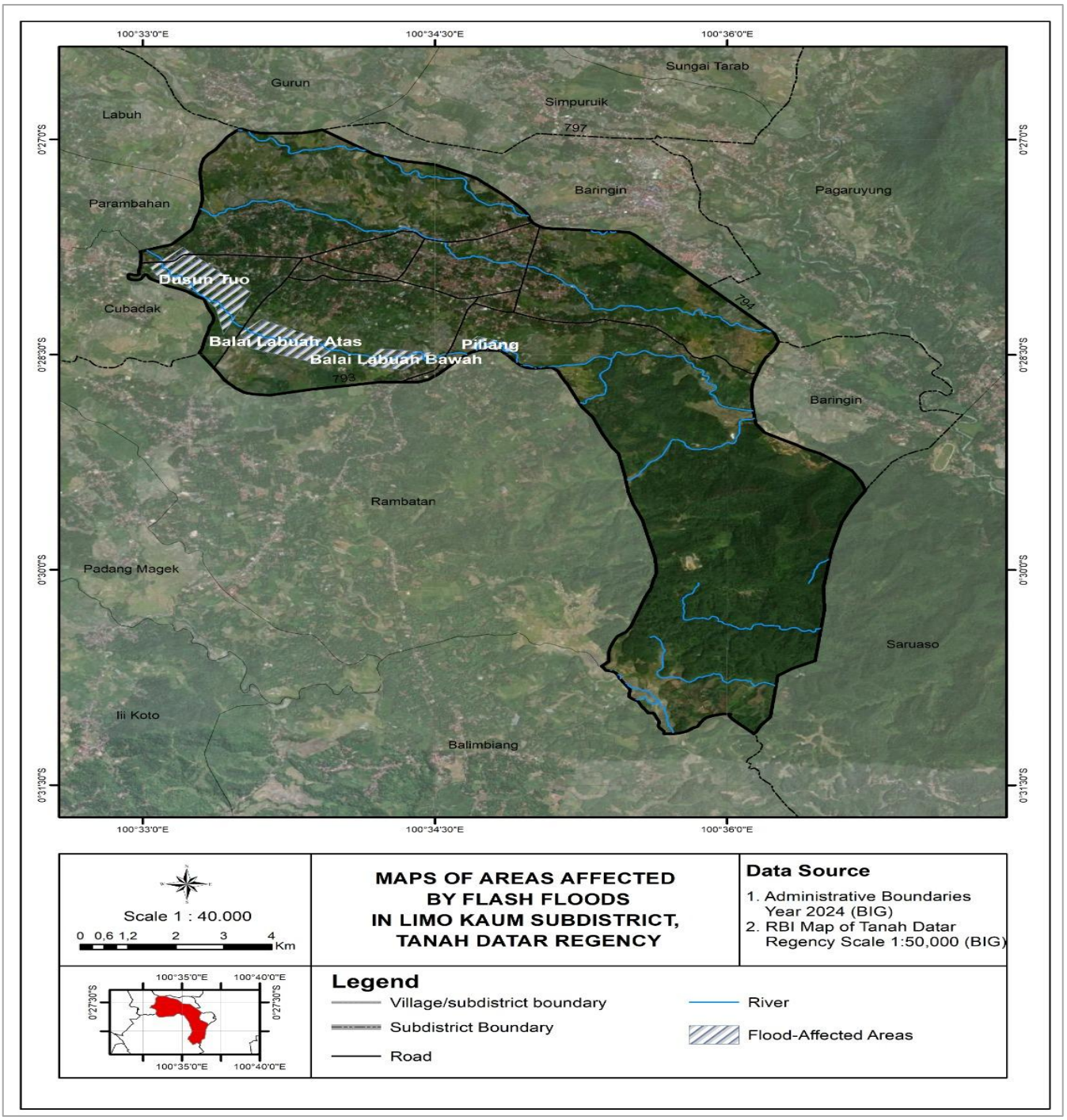

Figure 1. Distribution of Areas Affected by the Flash Flood in Nagari Limo Kaum

Post-Flash Flood Management

The post-disaster management system in Nagari Limo Kaum, Tanah Datar Regency, is implemented through three main phases: emergency response, rehabilitation, and reconstruction. The emergency response phase is carried out by the Regional Disaster Management Agency (BPBD), the Indonesian National Armed Forces (TNI), the Indonesian National Police (Polri), and volunteers, with primary activities including the evacuation of victims, the establishment of command posts, and the distribution of relief supplies. The rehabilitation phase involves debris removal, the repair of temporary access roads, and the construction of emergency shelters, while the reconstruction phase

focuses on rebuilding permanent infrastructure, repairing drainage channels, and reinforcing river embankments.

The main challenges faced include a shortage of heavy equipment, delays in the disbursement of funds, a lack of spatial risk data, and limited land available for relocation. Although implementation has been guided by Law No. 24 of 2007 on Disaster Management, cross-sectoral coordination at the local level remains suboptimal. One of the factors exacerbating the impact of flash floods is anthropogenic activity in the upstream areas, such as clearing forest land for agriculture and plantations, logging without reforestation, and the construction of settlements along riverbanks, which increases erosion rates and leads to the accumulation of sediment and logs in river channels. These conditions reduce the river's capacity and increase the risk of flooding during extreme rainfall. By way of comparison, various countries have adopted different approaches to managing the aftermath of flash floods. International experience shows that the effectiveness of post-disaster recovery depends heavily on interagency coordination, the availability of spatial data, and the participation of local communities.

Table.3 Comparison of Post-Flood Disaster Management in Several Countries

No	Country / Location	Post-Disaster Response Priorities	Characteristics of the Approach / Strategy
1.	Japan (Kyushu Flood, 2020)	Infrastructure and clean water system recovery	Inter-agency coordination and rapid GIS-based information systems
2.	Philippines (Cagayan Valley, 2022)	Socio-economic rehabilitation of affected communities	Community-based recovery approaches and community preparedness training
3.	India (Kerala Flood, 2020)	Reconstruction of homes and public facilities	Planned relocation programs with funding from the central government
4.	Nepal (Melamchi Flood, 2023)	Livelihood and infrastructure recovery	Integrated rehabilitation based on local participation
5.	Bangladesh (Sylhet, 2022)	Recovery of agricultural land and household assets	Direct cash assistance and community-based early warning systems
6.	United States (Louisiana Flood, 2020)	Reconstruction of housing and urban infrastructure	Integration of spatial risk data for determining relocation zones
7.	Pakistan (Sindh Flood, 2022)	Housing and sanitation rehabilitation	Government–NGO partnerships in logistics distribution and reconstruction
8.	Australia (Queensland Flood, 2022)	Recovery of infrastructure and the local economy	Integrated response based on regional contingency plans

The main causes of flash floods in Nagari Limo Kaum are high-intensity rainfall, the low-lying topography near river channels, and the accumulation of sediment and timber from upstream due to land erosion. Illegal logging in the upstream area further exacerbates vulnerability by reducing soil absorption capacity and increasing the volume of material carried by the floodwaters. Vulnerability is further heightened by the lack of adequate flood control infrastructure, such as sabo dams, levees, and drainage systems. To reduce these risks, recommended mitigation efforts include the construction of sabo dams, river channelization, reinforcing levees at vulnerable points, and rehabilitating upstream forests as natural buffers. On the non-structural side, community capacity must be strengthened through ongoing public awareness campaigns, evacuation drills, training in the use of early warning systems (EWS), and the utilization of Geographic Information Systems (GIS) for mapping high-risk zones. Thus, mitigation strategies can serve as the foundation for relocation planning and support the "Build Back Better" concept in post-disaster reconstruction.

CONCLUSSION

The results of the study on the spatial distribution of flash floods in Nagari Limo Kaum provide a fairly clear initial picture of the affected areas, particularly in Jorong Dusun Tuo, as well as the impact on homes, farmland, roads, and waterways, which has disrupted inter-regional access. Post-disaster management has also progressed through the emergency response, rehabilitation, and reconstruction phases, although there are still many shortcomings, particularly regarding inter-agency coordination and the slow distribution of aid. These findings are certainly useful, but they still have several limitations. The spatial analysis conducted relies largely on secondary data and remote sensing imagery, so the details of damage conditions on the ground are not yet fully and accurately represented, particularly at the household level and for small public facilities. The research also focuses more on the physical and spatial aspects of flood impacts, while socio-economic dimensions such as household vulnerability, livelihood patterns, and community adaptive capacity have not been fully examined in depth. Furthermore, the study on post-disaster management remains descriptive and lacks quantitative indicators to measure the effectiveness of inter-agency coordination or the interventions that have been implemented..

Given these limitations, future research is recommended to integrate spatial analysis with primary data from field surveys and community-based participatory mapping, thereby ensuring greater validity of the results. Future studies should also expand their scope to include the socioeconomic aspects of affected communities by examining levels of vulnerability, resilience, and the impact of flooding on food security and income. Additionally, the development of performance evaluation indicators for inter-agency coordination and the effectiveness of post-disaster programs is necessary to ensure that the resulting recommendations are more measurable and practical. An interdisciplinary approach combining geospatial technology, institutional analysis, and community participation is expected to make a tangible contribution, not only to enriching the academic literature but also to the formulation of more effective and contextually appropriate post-disaster management strategies for Nagari Limo Kaum and other regions with similar characteristics.

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Conflict of interest The author has no competing interests to declare that are relevant to the content of this article.

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